EXHIBIT 4

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Klicpera

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(54) **WATER USE MONITORING APPARATUS**

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(51) **Int. Cl.**

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(52) **U.S. Cl.**
CPC ***B05B 12/02*** (2013.01); ***B05B 12/004*** (2013.01); ***B05B 12/008*** (2013.01); ***B05B 12/12*** (2013.01); ***E03B 7/04*** (2013.01); ***E03C 1/0408*** (2013.01); ***G01F 15/024*** (2013.01); ***G01F 15/063*** (2013.01); ***G01F 15/075*** (2013.01); ***G01F 15/0755*** (2013.01); ***G01K 13/02*** (2013.01); *B05B 1/18* (2013.01); *E03C 2001/0418* (2013.01); *G01K 13/026* (2021.01); *G01K 2207/00* (2013.01); *Y02A 20/00* (2018.01); *Y10T 137/8158* (2015.04)

(58) **Field of Classification Search**
None
See application file for complete search history.

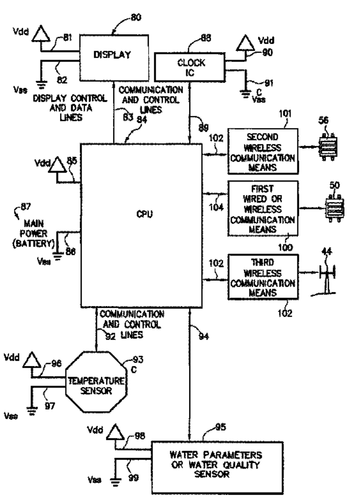
(56) **References Cited**

To view the complete listing of prior art documents cited during the proceeding for Reexamination Control Number 90/014,351, please refer to the USPTO's public Patent Application Information Retrieval (PAIR) system under the Display References tab.

Primary Examiner — Angela M Lie

(57) **ABSTRACT**

A water use and/or a water energy use monitoring apparatus that is affixed to the hot and cold main water supply piping for continuously (or on demand) monitoring and displaying the water use within a residential or commercial building. A first wire or wireless communication is incorporated to electronically communicate with a remote display for viewing by the owner of a commercial building or occupier/resident of a home. A second optional wire or wireless communication can be incorporated that can be monitored by civil, commercial, governmental or municipal operators or agencies, using a remote display and/or recorder or by a secure wire or wireless communication network (e.g. cell phone communication technology). A third wireless communication can be incorporated to electronically communicate water parameter data utilizing typical cell tower technology and/or mesh network technology.



EX PARTE REEXAMINATION CERTIFICATE

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

ONLY THOSE PARAGRAPHS OF THE SPECIFICATION AFFECTED BY AMENDMENT ARE PRINTED HEREIN.

Column 1, lines 32-45:

Several municipalities are considering or have enacted water conservation laws or ordinances. For example, the city San Diego, Calif. has considered enacting an ordinance requiring new multi-housing to include a secondary means for monitoring water use. Florida's Miami-Dade County Ordinance 08-14, effective on Jan. 1, 2009, [defined] *required* restricted toilet, urinals, faucet and shower head water flow. California Assembly Bill 715 phases in lower flush volume requirements for water closets and urinals. Texas House Bill 2667 mandates showerhead ratings of <2.5 gallons per [minutes] *minute* and urinal flush volumes <0.5 gallons per flush. Los Angeles Calif.'s High Efficiency Plumbing Fixtures Ordinance contains requirements to install high efficiency water fixtures for all new buildings and renovations.

Column 1, lines 59-67 to column 2, lines 1-4:

The solid-state digital Smart Meter™ electric meter records hourly meter reads and periodically transmits [the reads] via a dedicated radio frequency (RF) network back to a defined municipality. Each SmartMeter™ electric meter is equipped with a network radio, which transmits *electric* meter data to an electric network access point. The system uses RF mesh technology, which allows meters and other sensing devices to securely route data via nearby meters and relay devices, creating a "mesh" of network coverage. The system supports two-way communication between the meter and PG&E. SmartMeter™ electric meters can be upgraded remotely, providing tae ability to implement future innovations easily and securely.

Column 2, lines 5-19:

The electric *meter* network access point collects meter data from nearby electric meters and periodically transfers this data to defined municipality via a secure cellular network. Each RF mesh-enabled device (meters, relays) connected to several other mesh-enabled devices, which function as signal repeaters, relaying the data to an access point. The access point device aggregates, encrypts, and sends the data back to thee defined municipality over a secure commercial third-party network. The resulting RF mesh network can span large distances and reliably transmit data over rough or difficult terrain. If [a] *an electric* meter or other transmitter drops out of the network, its neighbors find another route. The mesh continually optimizes routing to ensure information is passed from its source to its destination as [quickly and] efficiently as possible.

Column 3, lines 6-61:

The present invention comprises a water use and water energy use monitoring display apparatus having a base station attached to a water supply with wireless or wire capability to communicates with one or more remote display [and for] *and/or* recording apparatus devices. More specifically the present invention is a water use and/or a water energy use monitoring apparatus base station that is affixed to the water supply piping (connected to either connected to the cold and hot water supply lines) for continuous, or on demand, monitoring the water and water energy (hot vs. ambient) or in another embodiment the single water supply line used within a residential or commercial building. In addition, the present invention could be used with non-commercial water sources such as private cells and other non-commercial water sources. The water use and water energy use monitoring display apparatus base station can optionally have a display [means] for displaying a plurality of water parameters. A first wire or wireless [means] *communication technology* is incorporated to a remote display and/or recording display for viewing water parameter data by the commercial owner, occupier, or home/apartment/condominium resident. A second wire or wireless [means] *communication technology* is designed for monitoring and recording water parameter data by civil, commercial, governmental, or municipal operators or agencies, using a remote display and/or recorder means connected by a secure wire or wireless communication network. A third wireless communication [means] *technology* is designed to use cellular format technology to transmit water and water energy parameter data to a remote location. The housing of the water use monitor apparatus base station or the display/recording remotes can be fabricated from materials (e.g. a polymeric or metallic or any combination and possibly include chrome, brass white or colored finishes or combination of these finishes and materials of construction). The water use monitor apparatus base station includes a power generation, a microprocessor, temperature sensor, water flow sensor and optional water quality sensors, optional [high] *highly water* sensitive *and specifically located* water flow [sensor] *sensors* for detecting leaking conditions and providing a separate data for indoor and outdoor water use, timing circuits, wireless circuitry, and an optional display means. Ergonomically placed buttons or touch screen technology can be integrated with this optional display as the base station or the display and recording remotes to change parameter units (e.g. metric to US), set alarm conditions (e.g. volume set points), calibrate sensor and program features (e.g. change the language, input a cell, mobile or standard telephone number for certain communications). A first wired or wireless means is designed to electronically communicate the water use and/or water energy use information to a remotely located display for convenient observation by a commercial operator or occupier, or home/apartment/condominium resident. A secondary wireless means is designed to [electronically and wirelessly] communicate water and water energy use information *electronically and wirelessly* to governmental or municipal operators or agencies. A third wireless means is designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like.

Column 4, lines 14-18:

FIG. **2** is a front view of a water use and water energy use monitoring display apparatus base station showing input hot and cold water [supplies] *supply* lines and output hot and cold water supply lines with a display means having one or display screens and a plurality of hardware and/or software buttons.

Column 4, lines 46-47:

DETAILED DESCRIPTION OF THE PREFEREDED EMBODIMENTS

Column 4, lines 59-61:

Encryption refers to a privacy technology that prevents [anyone] *any individual* but the intended recipient(s) to download, review or read a confidential information, signal and/or data.

Column 4, lines 62-65:

Authentication refers to the technology that ensures that a message(s), data or control or information that is downloaded or transferred from one [person] *individual* or device, to another declared or intended [person] *individual* or device.

Column 4, lines 66-67:

Integrity refers to technology that ensures that a message, information, control command signal and/or data is not altered in any way, during [transit] *transmission.*

Column 5, lines 4-19:

Cellular format technology refers to all current and future variants, revisions and generations (e.g. third generation (3G), fourth generation (4G), fifth generation (5G) and all future generations) of Global System for Mobile Communication (GSM), General Packet Radio Service [(GPSR)] (*GPRS*), Code Division Multiple Access (CDMA), Evolution-Data Optimized (EV-DO), Enhanced Data Rates for GSM Evolution (EDGE), 3GSM, Digital Enhanced Cordless Telecommunications (DECT), Digital AMPS OS-136/TDMA, Integrated Digital [Enhance] *Enhanced* Network (iDEN), HSPA+, WiMAX, LTE, Flash-OFDM, HIPERMAN, Wifi, IBurst, UMTS, W-CDMA, HSPDA+HSUPA, UMTS-TDD and other formats for utilizing cell phone technology, antenna distributions and/or any combinations thereof, and including the use of satellite, microwave technology, the internet, cell tower, and/or telephone lines.

Column 5, lines 34-67 to column 6, lines 1-5:

Referring now to the drawings and particularly to FIG. **1** is a perspective view of the first embodiment comprising the [comprising the] water use monitoring display apparatus base station **10** affixed to the hot and cold (see second embodiment **126** in FIG. **6**) water supply piping in an appropriate location for water monitoring and for continuously monitoring of the water and water energy use within a residential or commercial building **40**. This can be useful for an individual or commercial operator [employing] *performing* water conservation methods (e.g. reduce the sprinkler frequency or duration, encourage individuals to take shorter showers, fix leaking devices). Alternately, the monitoring of indoor water use and outdoor water use could be utilized by the particular water supplying municipality or government agency to apply different rates for indoor water use and outdoor water use. In addition, since many municipal agencies include a sewer cost in a ratio of the total supply use, the difference between indoor water use and outdoor water use can [reduced] *reduce* the total sewer cost associated with only the indoor use, thus saving the consumer costs. In certain situations, a control valve can be located at a [particular] location, e.g. the irrigation valve or ball valve whereby by utilizing the two-way wireless capability of the present invention apparatus **10**, **126** whereby the owner, water supplying municipality or government agency can remotely control water use (e.g. turn the main water supply off after a leaking notice, send out a code that inhibits outdoor water use on certain days or at certain hours of the day). For accurate measurements of water use or water energy use the present invention should be installed between the pressure reducing valve or civil, commercial, governmental, or municipal supply water sources (with potential meter) and/or any distribution lines. It is also anticipated by the Applicant that present invention can be used on wells and in situations where the water source is not obtained from a commercial gar municipal operation [s]. The water use and water energy use monitoring apparatus base station **10**, **126** can update, upload or download water and energy use on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing the initiation of water use ([after no] *until water use is stopped* water use period) on the display/recorder screen (shown in FIG. **2**).

Column 6, lines 6-43:

Also shown in FIG. **1** is a first wired or wireless communication means **52** from the water use and water energy use monitoring apparatus base station **10**, **126** for communicating water use and water energy use information or data to a conveniently located first display and/or recorder apparatus **50** (defined in more detail in FIG. **5**) located in a convenient location for the commercial operator or occupier or residential individual to observe daily, weekly, monthly or annual water use. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. The first wireless communication means **52** preferably utilizes encryption, [authentic] *authentication*, integrity and non-repudiate techniques to provide a secure transfer of the water and energy use from the water/energy use from the monitoring base station apparatus **10**, **126** to the first remote and/or recorder **50**. The first wired or wireless communication means **52** can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing an initiation of a water use until water use is stopped (water use period) to the first remote and/or recorder **50** or atypical cell phone, smart phones, or [similar] other electronic apparatus (see FIG. **9**). Furthermore, the first wired or wireless communication means **52** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the first remote display and/or recorder **50** that transmits a request for water and energy use data to the water and energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of

wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireles devices, and reduce the exposure of wireless energy to individuals. Furthermore, the first wireless communication means **52** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the first display and/or recording apparatus **50** and similarly, and the first display and/or recording apparatus **50** can transmit and receive electronic signals from the monitoring display apparatus base station **10**, **126**. The first wired or wireless communication **52** can be either one-way (*half duplex*) transmission, or **[**half duplex and/or full duplex**]** two-way (*full duplex*) transmission.

Column 6, lines 44-67 to column 7, lines 1-21:

The second optional wireless communication means **54** is preferred to transit, upload or download water parameter data or information via a secure wireless communication network providing information to a governmental, civil or municipal employee or individual **60** using a second remote display and/or recorder apparatus **56** (or a typical cell phone, smart phones, or **[**similar**]** *other electronic* apparatus as shown in FIG. **9**) for property owners, governmental, civil, commercial or municipal operators or agencies purposes. It is anticipated that the second wireless communication means **54** can also be received by a moving vehicle or can communicate with cellular format technology utilizing cell towers **44** using another third wireless communication **46**. The second optional wireless communication means **54** preferably utilizes encryption, **[**authentic**]** *authentication* integrity and non-repudiate techniques to provide a secure transfer of the water and energy use from the water monitoring display base station **10**, **126** to the second remote display and/or recorder apparatus **56**. Also, the second wireless communication means **54** should include specific identification information e.g. house or commercial building address, IP address or other specific technology. The second optional wireless communication means **56** can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send informaton upon sensing an initiation *of a water use until water user is stopped* (*water use period*) to the second remote and/or recorder **56**. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies, such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. Furthermore, the second optional wireless **56** communication means can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the second remote display **50** and/or recorder **56** that transmits a request for water and energy use data to the water and energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the second wireless communication means **54** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the second optional display and/or recording apparatus **56** and similarly, and the second optional display and/or recording apparatus can transmit and receive electronic signals from the monitoring display apparatus base station **10**, **126**. **[**Hence the**]** *The* first wired or wireless communication **52** can be either one-way (*half duplex*) transmission, or **[**half duplex and/or full duplex**]** two-way (*full duplex*) transmission.

Column 7, lines 22-67 to Column 8, lines 1-3:

The third optional wireless communication means **46** is designed to communicate data under a cellular format technology with offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. It is anticipated that the third wireless communication means **46** can transmit information to a programmed cell or phone number for communicating water parameter data or alarm situations to the owner or a municipal/governmental agency (such as announcing a water leak situation). Also, the third wireless communication means **46** should include specific identification information e.g. house or commercial building address, IP address or other specific technology. The third wireless communication means **46** can send data, on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing the initiation *of water use until water use is stopped or upon an* **[**(**]** alarm situation **[**)**]** to the programmed cell or phone number. The water use and water energy use monitoring apparatus base station **10**, **126** can be programmed to communicate at other time frequencies,such as every 5 seconds or every minute, for various purposes, for example, to identify leaking conditions. The request signal can be generated by, for example, a request signal transmitted by a remote station (not shown). The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the third wireless communication means **46** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **10**, **126** can transmit and receive electronic signals from the remote station and similarly, the remote station can transmit and receive electronic signals from the water use and water energy use monitoring display apparatus base station **10**, **126**. The third wireless means **46** can also be designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. The third communication means **46** can also comprise a **[**RF**]** mesh-enabled *water* meter device **[**meter , relays) is**]** connected to several other mesh-enabled devices, which function as **[**signal**]** *data* repeaters, **[**relaying**]** *transferring* the data to an access point. The access point device aggregates, encrypts, and **[**sends**]** *transfers* the data **[**back**]** to a municipal or government agency over a secure commercial third-party network. The resulting **[**RF**]** mesh network can **[**span large**]** *extend over long* distances and reliably transmit the data **[**over rough or difficult terrain**]**. If a *water* meter or other transmitter drops out of the network, **[**its neighbor find**]** *it finds* another route. The mesh **[**continually periodically**]** *technology* optimizes routing to ensure **[**information**]** *data* is **[**passed**]** *transferred* from its source to its destination as **[**quickly and**]** efficiently as possible. Furthermore, it is anticipated that the third wireless means can "piggy back" or be designed to be incorporated into and/or cooperation with electric and gas smart meters communication/transmission mesh technology. This takes advantage of

the communication/transmission mesh means already in place thereby, minimizes cross talk and cross interference in wireless transmissions and minimized overall wireless signals in residential or commercial area. The terminal communication/transmission of water parameter data can *be* designed to be sent to a difference source, e.g. water municipality versus the electric or gas company. The third optional wireless communication can be either one-way transmission, or half duplex and/or full duplex two-way transmission. This third wireless technology **46** is designed for long range uses that can communicate with remote computers, for example, property owners, municipal and government uses, control, and billing practices. It is anticipated that the billing practices can be conducted by an independent corporate entity. This third wireless technology **46** can also be used to communicate with a home resident or corporate individual on their typical cell phone, smart phones, or similar apparatus **400** (see FIG. **9**).

Column 8, lines 23-51:

[There is a growing trend towards the use of**]** TCP/IP technology **[**as a**]** *is a* common communication platform for the present invention applications, so that the present invention can deploy multiple communication systems, while using IP technology as a common *software* management platform. Other solutions suggest the use of a single, universal connector separating the function of the smart **[**grid**]** *water meter* device and its communications module. A universal metering interface would allow for development and mass production of smart water meters **[**and smart grid devices**]** prior to the communication standards being set, and then for the relevant communication modules to be easily added (or switched when they are). This would lower the risk of investing in the wrong standard as well as permit a single product to be used globally even if regional communication standards vary. The cellular format technology or other communication means can be used to transfer or download water parameter data from a residence/commercial operation, or well operation, to a remote monitoring site, or used to upload data, information or software updates to the water use and water energy use monitoring display apparatus **10**, **126**. In addition, the water leak monitoring capability of the present invention, described below, can use the cell tower or other communications means to communicate an alarm or message that a leak has developed in the residential/commercial or well water system. This leak identification means can call either a programmed cell or phone number **[**,**]** or can send the alarm or message to a governing utility or municipality. Digital signals and data can be communicated directly through wiring or wireless means **46**, **52**, and **54**.

Column 10, lines 32-48:

Several different data formats **[**that**]** may be used to **[**exchange**]** *transmit* data, including **[**but not limited to: binary,**]** XML, XHTML and XHTML Basic, **[**XHTML Basic as an Info-set in another form besides tagged text, Binary encoded equivalents of XML Info-sets including Wireless Binary XML ("WBXML"), ASN.1 encoded XML, SVG,**]** Direct Internet Message Encapsulation ("DIME"), **[**CSV, XML RPC,**]** *Simple Object Access Protocol* SOAP (with signature at SOAP level and/or enclosed content level), SOAP (using WS-SECURITY with signature at SOAP level and/or enclosed content level), **[**application specific content like spreadsheet data, an**]** *a* HTTP response to an unsolicited

HTTP request, a response to an unsolicited message **[**, HHF, PQDIF,**]** MODBUS, ION.RTM., or other SCADA protocol where a response can be packaged up and embedded in another protocol or format. These formats are frequently sent as MIME or UUENCODE attachments and are considered part of the protocol stack.

Column 10, lines 49-54:

The water use and water energy use monitoring *apparatus 10, 126* activities will require security due to economic impact or violation of municipal or governmental law and ordinances or fraudulent activities. **[**SPOT is a technology that uses the FM band and is coupled with a new digital radio infrastructure.**]**

Column 10, lines 58-67 to Column 11, lines 1-3:

With Public Key Encryption, each user has a pair of keys, a public encryption key, and a private decryption key. **[**A**]** *Generally a* second user can send *to* the first user*,* a protected message by encrypting the message using the first user's public encryption key. The first user then decrypts the message using their private decryption key. The two keys are different, and it is **[**not possible to calculate**]** *difficult to determine* the private key from the public key. In most applications, the message is encrypted with a randomly generated **[**session**]** key, the random key is encrypted with the public key*0* and the encrypted message and encrypted key are sent to the recipient. The recipient uses their private key to decrypt the **[**session random**]** *randomly generated* key **[**, and the newly decrypted session key**]** to decrypt the message.

Column 11, lines 4-17:

Digital signatures **[**are provided by**]** *utilize* key pairs **[**as well,**]** and provide authentication, integrity*,* and non-repudiation. **[**In this case a**]** *A* sender signs a one-way hash of a message before sending it, and the recipient uses the sender's public key to decrypt the message and verify the signature. When signing large documents, it is known to take a one-way bash function of the plain text of the document and then sign the hash. This eliminates the need to sign the entire document. In some cases, the digital signature is generated by encrypting the hash with the private key such that it can be decrypted using the signers public key. These public/private key pairs and associated certificate key pairs may be computed using hard to reverse functions including prime number and elliptic curve techniques.

Column 11, lines 18-24:

One-way Hash Functions are small pieces of data that identify larger pieces of data and provide authentication and integrity. Ideal hash functions cannot be reversed engineered by analyzing bashed values **[**, hence the 'one-way' moniker.**]** An example of a one-way bash function is the Secure Hash Algorithm. X.509 and PGP each define standards for digital certificate and public key formats.

Column 11, lines 25-28:

Various encryption algorithms **[**such as**]** *include the original* RSA *algorithm*, Advanced Encryption Standard (AES),

Data Encryption Standard (DES) and Triple DES. RSA is a commonly used encryption and authentication system for Internet communications.

Column 11, lines 29-38:

[(Secure Sockets Layer ("SSL")] *Secure technologies include the Secure Sockets Layer ("SSL") which* creates a secure connection between two communicating applications. For the purposes of the disclosed embodiments, SSL and Transport Layer Security ("TLS") are *typically considered* equivalent. [These] *Both of these* protocols are employed by web browsers and web servers in conjunction with HTTP to perform [cryptographically] secure web transactions. A web resource retrievable with HTTP over TLS is usually represented by the protocol identifier "https" in the URL. [TLS can and is used by a variety of Application protocols.)]

Column 11, lines 51-57:

Another security technology is the Internet Protocol Security ("IPSec") *which* secures IP traffic across the Internet, and is particularly useful for implementing [VPNs] *virtual private networks ("VPNs")*. Point-to-Point Tunneling Protocol ("PPTP") is *another* secure protocol that allows entities to extend their local network through private "tunnels" over the Internet. Layer Two Tunneling Protocol (L2TP) is an extension of the PPTP protocol.

Column 11, lines 61-67 to column 12, lines 1-8:

The [XML Signature syntax] *eXtensible Markup Language (XML)* associates a [cryptographic] signature value with Web resources using XML markup. XML signature [also] provides for the signing of XML data, whether that data is a fragment of the document which also holds the signature itself or a separate document, and whether the document is logically the same but physically different. This is important because the logically same XML fragment can be embodied differently. Different embodiments of logically equivalent XML fragments can be authenticated by converting to a common embodiment of the fragment before performing cryptographic functions. XML Encryption provides a process for encrypting/decrypting digital content, including XML documents and portions thereof, and an XML syntax used to represent the encrypted content and information that enables an intended recipient to decrypt it.

Column 12, lines 9-15:

Before the water use and water energy use monitoring apparatus base station **10**, **126** [and] *securely communicates and the* remote displays and/or recorders **52**, **54** (and **110** as shown in detail in FIG. **5**) or cell phone, smart phone, or other [similar] *electronic* apparatus (see FIG. **9**) [should communicate securely with one another] and therefore they need to be provided with *unique* identities. [The identity must not he easy to assume either intentionally or accidentally.]

Column 12, lines 16-24:

[Identities] *Residential and corporate identification* are particularly [relevant] *important* in multi-site scenarios, where the water use, water energy monitoring apparatus base station **10**, **126** are [aggregated] *located* across a wide geographic area containing mul multiple sites serviced by multiple utilities. *Each* water use, water energy monitoring apparatus basestation **10**, **126** will need to identify itself when transmitting water use or water quality data or information, or queried by a civil, commercial, municipal, or governmental operator or agency.

Column 12, lines 45-53:

PKI certificate-based authentication [schemes] *technologies* are *generally* utilized for machine-to-machine authentication *operations*. The water/energy use monitor and/or leak detection apparatus **10**, **126** is issued one or more PKI certificates [,] *with* associated identities and identity-related [secrets, such as] private keys, during manufacturing. Alternately, an identity and certificate are assigned by an authority unrelated to the device manufacturer and transferred to water monitor and/or leak detection apparatus **10**, **200** in a manner that keeps all secrets private.

Column 12, lines 54-67 to column 13, lines 1-3:

A user registry [maintains a database of] *database is manintained for* device identities associated with the installation and operation of the water use and water energy use monitoring apparatus base station **10**, **126**. [The] *This* registry may be updated whenever a water use or water energy use apparatus base stations **10**, **126** is brought into or removed from service. The registry may be implemented as a [distributed] registry with a host name encoded within the *water* meter [Metering Point corresponding to a registry for that particular host]. Alternatively, the registry can be implemented as a single large database. [Alternatively, the] *The* registry can be implemented as a relational database, XML files, Comma Separated Value ("CSV") files, or Resource Description Files ("RDF"), or any mechanism that allows associated lookup when combined with the appropriate software. The registry enforces uniqueness of [metering points] *water meters*, thereby preventing two devices from having the same identification address at the same instant.

Column 13, lines 4-26:

Encryption, authentication, integrity, and non-repudiation [may be] *are* important characteristics when the water/energy use monitor and/or leak detection base station apparatus **10**, **126** *is* sharing data or information with the remote [displays] *display devices 400, 480*. When a water use and water energy use monitoring apparatus base station **10**, **126** receives or uploads data and information such as a control command signal to send or transmit data and information it is critical that the device can authenticate the sender and [be sure of] *ensure* the integrity of the data and information. Encryption provides privacy by preventing anyone but the intended recipient of a message from reading it. Encryption can be provided point-to-point, or end-to-end, depending on the nature of the channel and the data. Only a portion of the data may be encrypted. [EM] Components can encrypt messages using encryption schemes such as PGP, S/MIME, XML Encryption, or SSL. Signing data provides assurance that the data comes from the desired source, and that it has not been tampered with. Signing helps prevent [so-called "man in the middle"] attacks where someone with legitimate or illegitimate access to data intercepts the data and tampers with [it or forges] *the* data. This can occur with all aspects

of communication, including installing certificates, and exchanging frameworks and all types of [EM] *transmitted* data.

Column 14, lines 11-36:

Software may be designed to check for valid signatures before an upload is attempted, and only allow certain users to upload unverified firmware. The firmware itself may verify signatures to ensure firmware has not been tampered with and is from an authorized source, and that the entity attempting the upgrade is authorized to perform an upgrade. Third parties may upload their own firmware written in their language of choice, such as Java, Pro log, Haskell, binary executable code, *or* C#, ECMA Common Language Runtime[“ECMA CLR”)], or ION® Object Configurations. Depending on the platform, source code or some repurposed version of the source code [(i.e. ECMA CLR or target processor machine code)] is digitally signed by the party and uploaded. Such code would be allowed to perform only specific actions based on trust level of the signer. For example, unsigned code or code signed by a non-trusted entity will not be allowed to read the second wireless communication mean **54** or the third wireless communication means **46**. [In additional, the] *The* water *use* and *water* energy *use* monitoring base station **10**, **126** or the first remote display and/or recording means **50** could has a microprocessor that includes a data memory bank for [are calling] *recording* the water and/or energy use parameter data [that] *which* can be compared with the data that is uploaded by the government or municipal second remote display/recorded means **56** or the data the is uploaded by the wireless cellular format communication means **46** [remote states].

Column 14, lines 46-67 to column 15, lines 1-16:

As shown in FIG. **1** but applicable to FIG. **6**, is a first wired or wireless communication means **52** from the water use and water energy use monitoring apparatus base station **126** for communicating water use information or data to a conveniently located first remote display and/or recorder apparatus **50** (defined in more detail in FIG. **5**) located in a convenient location for the commercial operator or occupier or residential individual to observe daily, weekly, monthly or annual water use. The first remote display and/or recorded apparatus **50** can be a typical cell phone, smart phone, or similar apparatus (see FIG. **9**) that is using wireless, Bluetooth technology or other wireless technology. The first wireless communication means **52** preferably utilizes some confidential technology such as encryption, [authentic] *authentication*, integrity and non-repudiate techniques to provide a secure transfer of the water use from the monitoring base station apparatus *10,* **126** to the first remote display and/or recording apparatus **50**. The first wired or wireless communication means **52** can send data on various frequencies, e.g. once per minute, once per hour, once per day, once per week, one per month/year or can send information upon sensing an initiation *of a water use until water use is stopped* (*water user period*) to the first remote and/or recording apparatus **50**. Furthermore, the first wired or wireless communication means **52** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the first remote display and/or recording apparatus **50** that transmits a request for water use data to the water and water energy monitoring apparatus base station **10**, **126**. The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the first wireless communication means **52** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the first display and/or recordirecording apparatus **50** and similarly, and the first display and/or recording apparatus **50** can transmit and receive electronic signals from the monitoring display apparatus base station *10,* **126**. [Hence, the] *The* first wired or wireless communication **52** can be either one-way (*half duplex*) transmission, or [half duplex and/or full duplex] two-way (*full duplex*) transmission.

Column 15, lines 17-60:

As shown in FIG. **1** but applicable to FIG. **6**, the second optional wireless communication means **54** is prefersd to transmit, upload or download water parameter data or information via a secure wireless communication network providing information to a property owner, governmental, civil or municipal employee or individual **60** using a second remote display and/or recorder apparatus **56** for governmental, civil, commercial or municipal operators or agencies purposes. It is anticipated that the second wireless communication means **54** can also be received by a moving vehicle or can communicate with cellular format technology utilizing cell towers **44** using another third wireless communication **46**. The second optional wireless communication means **54** preferably utilizes some confidential technology such as encryption, [authentic,] *authentication,* integrity and non-repudiate techniques to provide a secure transfer of the water use from the monitoring base station apparatus **126** to a second display and/or recorder **56**. The second display and/or recorded can be a typical cell phone, smart phone, or similar apparatus (see FIG. **9**) that is using wireless, Bluetooth technology or oher wireless technology. Also, the second wireless communication mean **54** should include specific identification information e.g. house or commercial building address, IP address or a similar unique technology. The second optional wireless **56** communication means can send data on various frequencies, e.g. once per minute, once per hour, once per day, or can send information upon sensing an initiation *of a water use until water use is stopped* (*water use period*) to the second remote and/or recorder **56**. Furthermore, the second optional wireless communication means **56** can send data or information upon the sending of a request signal. The request signal can be generated by, for example, the pushing of a requesting button located on the second remote display and/or recorder **56** that transmits a request for water use data to the water and energy monitoring apparatus base station **126**. The use of the request signal can minimize the use of wirelesss signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the second wireless communication means **54** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the second display and/or recording apparatus **56** and similarly, and the second display and/or recording apparatus **56** can transmit and receive electronic signals from the monitoring display apparatus base station *10,* **126**. [Hence, the]

The first wired or wireless communication **52** can be either one-way (*half duplex*) transmission, or [half duplex and/or full duplex] two-way (*full duplex*) transmission.

Column 15, lines 61-67 to Column 16, lines 1-42:

As shown in FIG. 1 but applicable to FIG. **5**, is the third optional wireless communication means **46** is designed to communicate data under a cellular format technology with offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. It is anticipated that the third wireless communication means **46** can transmit information to a programmed cell or phone number for communicating water parameter data or alarm situations to the property owner or a municipal/governmental agency (such as announcing a water leak situation). The information can be [send] *sent* to a typical cell phone, smart phone, or similar apparatus (see FIG. **9**). Also, the third wireless communication means **46** should include specific identification information e.g. house or commercial building address. IP address or similar unique technology. The third wireless communication means **46** can send data on various frequencies, e.g. once per minute, once per hour, once per day, once per week, once per month/year or can send information upon sensing the initiation [(]*of a water use until water use is stopped water use period or upon an* alarm situation[)] to the programmed cell or phone number. The request signal can be generated by, for example, a request signal transmitted by a remote station (not shown). The use of the request signal can minimize the use of wireless signals within the house or commercial building, conserving energy, minimizing the interference with other wireless devices, and reduce the exposure of wireless energy to individuals. Furthermore, the third wireless communication means **46** can consist of two-way transmission, commonly known as transceiver technology, such that the monitoring display apparatus base station **126** can transmit and receive electronic signals from the remote station and similarly, the remote station can transmit and receive electronic signals front the water use and water energy use monitoring display apparatus base station **126**. The third wireless means **46** can also be designed for communicating to an offsite central monitoring computer or cell, mobile or other telephone lines via satellite, microwave technology, the internet, cell tower, telephone lines, and the like. The third communication means **46** can also comprise a [RF] mesh-enabled [device (water meters, relays) is] *water meter and relay device that are* connected to several other mesh-enabled devices, which function as [signal] *data* repeaters, [relaying] *transmitting* the data to an access point. The access point device aggregates, encrypts, and [sends] *transfers* the data [back] to a municipal or government agency over a secure commercial third-party network. The resulting [RF] mesh network can [span large] *extend over long* distances and reliably transmit the data [over rough or difficult terrain]. If a *water* meter or other transmitter drops out of the network, [its neighbor find] *it finds* another route. The mesh [continually periodically] *technology* optimizes routing to ensure [information] *data* is [passed] *transferred* from its source to its destination as [quickly and] efficiently as possible. The third optional wireless communication can be either one-way (*half duplex*) transmission, or [half duplex and/or full duplex] two-way (*full duplex*) transmission.

Column 20, lines 29-51:

In addition, the water use monitoring display apparatu **10**, **126** can include water [shut off means] *control valve mechanism* to turn off the water supply if an alarm condition or setting point is exceed and has been activated. The water shut off means is electrically connected to the CPU or microprocessor **84** and the power means thereby controlling the application of electrical power to activate or de-activate the water shut off means. The water [shut off means] *control valve mechanism* can comprise, for example, a typical ball valve or solenoid shut off valve incorporate to the connection union such that water from the source is closed [such that no water enters a structure]. The water [shut off means] *control valve mechanism* can be activated if [a leak is observed and] an alarm state has been achieved, e.g. 200 gals/day of water is exceeded or the total of 15 gallons of water has flowed since the water source was closed. The alarm or settingss can be a default setting installed by the manufacturer or programmed by the user. The water [shut off means] *control valve also* can be activated by software instructions[,] or initiated by a command communicated over the optional second **54** and third **46** wireless [means] *technology. Therefore, using the wireless technology, the water control valve mechanism can be regulated by remotely received instructions.* As an example, many irrigation manufactures (Orbit, Hunter irrigation products) incorporate battery control valves and there are numerous other flow valves using standard electrical energy are available, e.g. ball valves, gate valves, butterfly valves.

Column 22, lines 4-24:

Technologies that can be use as the timing [sensor] *clock IC* **88** include electrical resistance sensors, ohm meter, [multi-meter] electrical current sensors, galvanometer, ammeter, electrical voltage sensors [: leaf electroscope, voltmeter] electrical power sensors, watt-hour meter magnetism sensors, magnetic compass, fluxgate compass, magnetometer, Hall effect device. [In addition, various chemical technologies, such as oxygen sensors, ion-selective electrodes, and redox electrodes might be used.] Furthermore, optical [radiation] technology can be used as the timing sensor, such as light sensors, on photo-detectors including semi-conduction devices such as photocells, photodiodes, [phototransistars, CCDs, and image sensors; vacuum tube devices like photo-electric tubes, photomultiplier tubes,] and mechanical instruments such as [the Nichols radiometer,] infra-red sensors, especially used as occupancy sensors for lighting and environmental controls [, interferometrv-interference fringes between transmitted and reflected lightwaves produced by a coherent source such as a laser are counted and the distance is calculated]. In addition, fiber optic sensors are capable of extremely high precision.

Column 22, lines 53-57:

Technological progress allows for more [and more] *sensors* to be manufactured on the microscopic scale as microsensors using MEM technology. In most cases a microsensor [reaches] *results in* a significantly higher speed and sensitivity compared with macroscopic approaches.

Column 22, lines 58-67 to Column 23, lines 1-2:

There are many types of sensors that can be used with the present invention. Since a significant small change involves an exchange of energy, sensors can be classified according to the type of energy transfer that they detect. For measuring or monitoring the temperature of the water [flowing through the water meter from the shower or bath head,] the use of various thermocouples or thermistor sensors **70** as depicted in FIG. **3** is protruding within the water supply lumen **38** (or

in close proximity to the water to be measured) and mounted within the arliculatiug joint mechanism **22**. Wires **71** are shown extending from the sensor **70** to electronically communicate with the CPU or microprocessor **84** and display unit.

Column 23, lines 3-21:

[In 1821, the German-Estonian physicist Thomas Johann Seebeck discovered] *It has been long known* that when any conductor (such as a metal) is subjected to a thermal gradient, it will generate a voltage. [This is now known as the thermoelectric effect or Seebeck effect.] Any attempt to measure this voltage necessarily involves connecting another conductor to the "hot" end. This additional conductor will then also experience the temperature gradient, and develop a voltage of its own which will oppose the original. Fortunately, the magnitude of the effect depends on the metal in use. Using a dissimilar metal to complete the circuit will have a different voltage generated, leaving a small difference voltage available for measurement, which increases with temperature. This difference can typically be between 1 and 70 micro-volts per degree Celsius for the modern range of available in metal combinations. Certain combinations have become popular as industry standards, driven by cost, availability convenience, melting points, chemical properties, stability, and output.

Column 25, lines 15-20:

A thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature. [Thermistor is a combination of time words thermal and resistor. The thermistor was invented by Samuel Ruben in 1930, and was disclosed in U.S. Pat. No. 2,021,491.]

Column 25, lines 21-29:

If we assume that *using* the relationship between resistance [amid] *and* temperature is *a* linear [(i.e. we make a first-order approximation),] *response* then [we can say that] *the formula is*:

$\Delta R—K\Delta T$

Where:

ΔR *represents the* change in resistance

Δ[=] *represents the* change in temperature

ΔK [k =] *represents the* first-order temperature coefficient of resistance

Column 25, lines 46-52:

It is anticipated by the Applicant that various types of thermocouples or thermistors can be used for the present invention. It is not important what type of thermocouple or thermistor is utilized for monitoring or measuring the temperature of the water entering the [shower head, bath head or] water supply lines except that it is accurate for the appropriate temperature range monitored or measured.

Column 25, lines 53-59:

In order to monitor or measure the flow rate of the water being delivered by the water supply line various flow measuring technologies arm applicable to the present invention. For measuring or monitoring the rate of the water flowing through the [shower or bath head, the use of various venturi] *flow* sensors or pressure sensors **74** as depicted in FIG. **4** [are] *should be* positioned in close proximity to the water *source* to be measured.

Column 25, lines 60-67 to column 26, lines 1-6:

One means to monitor flow parameter is to create a venturi, which constricts the flow in some fashion, and measure the differential pressure that results across the constriction. This method is widely used to measure flow rate in the transmission of gas or liquids trough pipelines [and has been used since Roman Empire times.] The venturi effect is [all example of] *based on* Bernoulli's principle, [in the case of] *wherein* incompressible fluid [flow] *flows* through a tube or pipe with a constriction in it. The fluid velocity must increase [through the constriction to satisfy the equation of continuity,] *as it passes through the tube or pipe,* while its pressure [must decrease due to conservation of energy: the gain in kinetic energy is supplied by a drop] *decreases* in pressure or a pressure gradient force. [The effect is named after Giovarmi Battista Venturi, (17 46-1822), an Italian physicist.]

Column 26, lines 7-13:

Using Bernoulli's equation in the special case of incompressible fluids [(such as the approximation of a water jet),] the theoretical pressure drop at the constriction would be given by the formula:

$$(p2)\ (v_2^2-v_1^2)$$

Column 26, lines 14-21:

In addition, the flow sensor **74** can be fabricated from pressure sensor technology. Pressure sensors are used in numerous ways for control and monitoring in thousands of everyday applications. Pressure sensors can be used in systems to measure other variables such as fluid/gas flow, speed, water level, and altitude. Pressure sensors can alternatively *be* called pressure transducers, pressure transmitters, pressure senders *or* pressure indicators [among other names].

Column 26, lines 22-27:

Pressure sensors can vary considerably in technology, design, performance, application, suitability and cost. [A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide.]

Column 26, lines 28-34:

[There is also a category of pressure] Pressure sensors [that are] *can be* designed to measure in a dynamic mode for capturing very high speed changes in pressure. Example applications for this type of sensor would be in the measuring of combustion pressure in an engine cylinder or in a gas turbine. These sensors are commonly manufactured out of piezoelectric materials like quartz.

Column 26, lines 40-67:

[In addition, various] Various flow measuring technologies can be utilized as the flow sensor **74**. In general, a flow sensor is a device for sensing the rate of fluid flow. Typically,

a flow [ensor] *sensor* is the sensing element used in a flow meter [, or flow logger, to record the flow of fluids]. There are various kinds of flow meters, including some that have [a vane, wheel or turbine structure] *an object* that is pushed by the fluid, and can drive a rotary [potentiometer] metering apparatus, or similar device. [Other flow] *Flow* meters *can* use a displacement piston, pushing it against a spring. Flow meters are related to devices called velocimeters that measure velocity of fluids flowing through them. [Laser-based interferometry is often used for air flow measurement, but for liquids, it is often easier to measure the flow.] Another approach is Doppler-based *ultrasonic technology* flow measurement. Hall effect sensors may also be used, on a flapper valve, or vane, to sense the position of the vane, as displaced by fluid flow. A fluid dynamics problem is easily solved (especially in non-compressible fluids by knowing the flow at all nodes in a network. Alternatively, pressure sensors can be placed at each node, and the fluid network can be solved by knowing the pressure at every node. [These two situations are analogous to knowing the currents or knowing the currents at every node (noncompressible fluid being conserved in the same manner as Kirchoff's current or voltage laws, in which conservation of fluid is analogous to conservation of electrons in a circuit).] Flow meters generally cost more than pressure sensors, so it is often more economical to solve a fluid dynamics network monitoring problem by way of pressure sensors, than to use flow meters.

Column 27, lines 4-13:

[Piston Meter—Due to the fact that they used for domestic water measurement.] Piston meters, (also known as Rotary Piston, or Semi-Positive displacement meters) are the most common in the UK and are used for almost all meter sizes up and including 40 mm (1½"). The piston meter operate on the principle of a piston rotating within a chamber of known volume. For each rotation, an amount of water passes through the piston chamber. Through a gear mechanism and, sometimes a magnetic drive, a needle dial and odometer type display [is] *are* advanced.

Column 27, lines 14-17:

[Woltmann Meter—Woltman meters, commonly referred to as] Helix meters are popular at larger sizes. Jet meters (single or Multi-Jet) are increasing in popularity in the UK at larger sizes and are commonplace in the EU.

Column 27, lines 18-19:

[Dall Tube—]A shortened form of the Venturi principal [. Lower] *known as the call tube monitors the* pressure drop across an orifice plate (useful differential pressure sensors).

Column 27, lines 20-25:

[Orifice Plate—]Another simple method of measurement uses an orifice plate, which is basically a plate with a hole through it. It is placed in the flow and constricts the flow. It uses the same principle as the venturi meter in that the differential pressure relates to the velocity of the fluid flow [(Bernoulli's principle)].

Column 27, lines 26-31:

[Pitot tube—]Measurement of the pressure [within] *with* a pitot Tube *can be* in the flowing fluid, or *within* the cooling of a heated element [by the passing fluid are two other methods that are used]. These types of sensors are advantageous in that they are rugged, so not easily damaged in an extreme environment. A pitot tube is *generally* an L shaped tube which is also able to measure fluid flow.

Column 27, lines 32-35:

[Paddle wheel—] The paddle wheel translates the mechanical action of paddles rotating in the liquid flow around an axis into a user-readable rate of flow (gprn, lpm, etc.). The paddle [tends to be] *is* inserted into the *water* flow.

Column 27, lines 36-40:

[The Pelton wheel,] The Pelton wheel turbine (better described as a radial turbine) translates the mechanical action of [the Pelton wheel] *a specifically shaped object* rotating in the liquid flow around an axis *that is translated* into *a* user-readable rate of flow (gpm, 1pm, etc.). The Pelton wheel tends to have all the [flow travelling] *water flowing* around it.

Column 27, lines 41-45:

[Turbine flow meter—]The turbine flowmeter (better described as an axial turbine) translates the mechanical action of the turbine rotating in the liquid flow around an axis into a user-readable rate of flow (gpm, 1pm, etc.). The turbine tends to have all the [flow travelling] *water flowing* around it.

Column 27, lines 46-53:

[Thermal mass flow meters—]Thermal mass flow meters generally use one or more heated elements to measure the mass flow of gas. They provide a direct mass flow readout, and do not need any additional pressure temperature compensation over their specified range. Thermal mass flow meters are used for compressed air, nitrogen, helium, argon, oxygen, natural gas. In fact, most gases can be measured as long as they a fairly clean and non-corrosive.

Column 27, lines 54-67 to column 28, lines 1-3:

[Vortex flowmeters—]Another method of flow measurement involves placing an object [called a shedder bar] in the path of the fluid. As the fluid passes this bar, disturbances in the flow called vortices are created. The vortices trail behind the cylinder in two rolls, alternatively from the top or the bottom of the cylinder. [This vortex trail is called the Von Kármán vortex street after von Karman's 1912 mathematical description of the phenomenon.] The speed at which these vortices are created is proportional to the flow rate of the fluid. Inside the shedder bar is a piezoelectric crystal, which produces a small, but measurable, voltage pulse every time a vortex is created. The frequency of this voltage pulse is also proportional to the fluid flow rate, and is measured by the flowmeter electronics. [With f=SV/L where, f=the frequency of the vortices L=the characteristic length of the bluff body V= the velocity of the flow over the bluff body S= Strouhal Number and is a constant for a given body shape.]

Column 28, lines 4-19:

In addition, various magnetic *and* and ultrasound [and Coriolis] flow meters can be utilized with the present

invention to function as the flow sensor **74**. Modern innovations in the measurement of flow rate incorporate electronic [devices] *circuitry* that can correct for varying pressure and temperature. (i.e. density) conditions, non-linearities, and for the characteristics of the fluid. [The most common flow meter apart from the mechanical flow meters, is the] *The* magnetic flow meter [, commonly referred to as a "mag meter" or an "electromag". A] *utilizes a* magnetic field [is applied to a tubular structure the has electrical insulating properties]. [the metering tube, which results in a potential difference proportional to the flow velocity perpendicular to the flux lines.] The [physical] *operating* principle [at work is] *follows* Faraday's law of electromagnetic induction. [The magnetic flow meter requires a conducting fluid, e.g. water, and an electrical insulating pipe surface, e.g. a rubber lined non magnetic steel tube.]

Column 28, lines 20-34:

[Ultrasonic flow meters—]The ultrasonic flow meters *can* measure the difference of the transit time of ultrasonic pulses propagating in and against flow direction. This time difference is [measure] *measured* for the average velocity of the [fluid along the path of] *water flowing through a specified path by* the ultrasonic beam. By using the absolute transit times both the averaged fluid velocity and the speed of sound can be calculated. [Using the two transit times tup and tdown and the distance between receiving and transmitting transducers L and the inclination angle a one can write the equations:

$$v = \frac{L}{2\sin(\&)} \frac{t_{up} - t_{down}}{t_{up} t_{down}} \text{ and } c = \frac{L}{2} \frac{t_{up} + t_{down}}{t_{up} t_{down}}$$

Where vis the average velocity of the fluid along the sound path and c is the speed ©f sound.]

Column 28, lines 37-49:

[Measurement] *Ultrasonic technology also utilizes measurement* of the doppler shift resulting in reflecting an ultrasonic beam off the flowing fluid is anothe [recent] innovation made possible by *use of modern* electronics. [By] *Doppler shift technology monitors water flow rate by* passing an ultrasonic beam through a water pipe, bouncing it off of a reflective plate then reversing the direction of the beam, and repeating the measurement *such that* the water flow can be estimated. The speed of transmission is affected by the movement of water in a supply line and by comparing the time taken to complete the cycle upstream versus downstream the flow of water through the water pipe can be measured. A wide-beam sensor can also be used to measure flow independent of the cross-sectional area of the water supply pipe.

Column 28, lines 50-57:

[Coriolis flowmeters.] Using the Coriolis effect causes a laterally vibrating tube to distort, a direct measurement of mass flow can be obtained in a Coriolis flow meter. [Furthermore] *In this way,* a direct measure of tide density of the fluid is obtained. Coriolis measurement can be very accurate irrespective of the type of gas or liquid that is measured; the same measurement tube can be used for hydrogen gas and peanut butter without recalibration.

Column 28, line 58-67 to Column 29, line 1-5:

[Laser-doppler flow meter.] Fluid flow *rate* can be measured through the use of a monochromatic laser diode. The laser probe is inserted into a water pipe and turned on, [where] *whereby* the *laser* light scatters and a [small] portion *that* is reflected back to the probe. The signal is then processed to calculate flow *rate* within the water pipe. There are limitations to the use of a laser [doppler] probe; flow within a water pipe is dependent on volume illuminated, which is often assumed rather than measured and varies with the optical properties of the [tissue] *water pipe*. In addition, variations in the type and placement of the probe within type and placement of the probe within identical water pipes *may* result in variations in reading. The laser doppler has the advantage of sampling a small volume of water, allowing for great precision, but does not necessarily represent the flow within an entire water system. The flow meter *using the laser diode* is more useful for relative rather than absolute measurements.

Column 29, lines 33-43:

[The] *Current* EPA [Secondary Regulations] *regulations* advise a maximum contamination Level [(MCL)] of 500 mg/liter [(] *to which is equivalent to* 500 parts per million [(ppm)) for TDS]. [Numerous water supplies exceed this level.] When TDS levels exceed 1000 mg/L it is generally considered unfit for human consumption. A high level of TDS is an indicator of potential concerns, and warrants further investigation. Most often, high levels of TDS are caused by the presence of potassium, chlorides, and sodium *ions*. These ions have little or no short-term effects, but toxic ions (lead arsenic, *and* cadmium, nitrate and others) may also be dissolved in the water.

Column 29, lines 40-52:

In addition, as shown in FIG. **4**, is an optional halogen (chloride or fluoride) sensor **76**. There are currently several types sensors and technology are available on the commercial market that can be used with the present invention as chlorine and fluoride are common compounds or elements that are added to the water supply [in an attempt] to maintain clean water. The sensor **76** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **77** (or wireless means) which includes specific software instructions to display the halogen parameter on one of the displays or provide an alarm that is programmed that is triggered when [an] *a* certain level or percentage is exceeded.

Column 29, lines 53-67 to Column 30, lines 1-32:

In addition, as shown in FIG. **4**, is an optional [Total Dissolved Solids] *total dissolved solids* (TDS) sensor **78** measures are the total amount of mobile charged ions, including minerals, salts or metals dissolved in a given volume of water, expressed in units of mg per unit volume of water (mg/L), also referred to as parts per million (ppm). TDS is [directly] related to the purity [of water] and the quality of water [purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse. Dissolved solids refer to any minerals, salts, metals, cations or anions dissolved in water. This includes anything present in water other than the pure water ($H2O$) molecule and suspended

solids. (Suspended solids are any particles/substances that are neither dissolved nor settled in the water, such as wood pulp.) In general, the total dissolved solids concentration is the sum of the cations (positively charged) and anions (negatively charged) ions in the water. Parts per Million (ppm) is the weight-to-weight ratio of any ion to water]. A TDS sensor or meter is based on the electrical conductivity [(EC)] of water [and can be a relatively simple conductivity meter.] Pure [H2O] *water* has virtually zero conductivity. Conductivity is [usually about] *generally* 100 times the total cations or anions expressed as equivalents. TDS is calculated by converting the [EC] electrical conductivity by a factor of 0.5 to 1.0 times the EC, depending upon the levels. [Typically, the higher the level of EC, the higher the 10 conversion factor to determine the TDS.] TDS comes from *many* organic sources such as leaves, silt, [plankton, and industrial waste and sewage. Other sourcescome from] runoff from urban areas, road salts [used on street. during the winter,] and fertilizers and pesticides used on lawns and farms[. Dissolved solids also come], from *numerous* inorganic materials such as rocks, and air that may contain calcium bicarbonate, nitrogen, iron phosphorous, sulfur, and other minerals. Many of these materials form salts, which are compounds that contain both a metal and a nonmetal. Salts usually dissolve in water forming ions. Ions are particles that have a positive or negative charge. Water may also pick up metals such as lead or copper as they travel through pipes used to distribute water to consumers. [Note that the efficacy of water purifications systems in removing total dissolved solids will be reduced over time, so it is highly recommended to monitor the quality of a filter or membrane and replace them when required.] The sensor **78** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126** through wired **79** (or wireless means) which includes specific software instructions to display the TDS parameter on one of the displays or provide an alarm that is programmed that is triggered when [an] *a* certain level or percentage is exceeded.

Column 30, lines 61-67 to Column 31, lines 1-55:

In addition, as shown in FIG. **4**, is a biological or fecal coliform (bacteria) sensor **132**. In general, increased levels of fecal coliforms provide a warning of failure water treatment, a break in the integrity of the distribution system, or possible contamination with pathogens. When levels are high there may be an elevated risk of waterborne diseases or [gastroenterisits] *gastroenteritis* . The presence of fecal coliform in water system may indicate that the water has been contaminated with the fecal material of humans or other animals. [Fecal] *Contamination* from coliform bacteria can [enter rivers or storm drains] *be sourced* through direct discharge of waste from mammals and birds, from agricultural [and storm] runoff, and from human sewage. Failing home septic systems can allow coliforms in the effluent to flow into the water table, aquifers, drainage ditches and nearby surface waters and can contaminate wells or water systems. [Sewage] *Some older industrial cities sewage* connections [that] are connected to storm drains pipes *that* can [also] allow human sewage into surface waters. Some older industrial cities [, particularly in the Northeast and Midwest of the United States,] use a combined sewer system to handle waste. A combined sewer carries both domestic sewage and stormwater. During high rainfall periods, a combined sewer drain can become over-loaded and overflow to a nearby stream or river, bypassing treatments. [Pets] *In addition, pets* can contribute to fecal contamination of surface waters. Runoff from roads, parking lots, and yards can carry animal wastes to streams through storm sewers. Birds can be a significant source of fecal coliform bacteria. Agricultural practices such as allowing livestock to graze near waterbodies, spreading manure as fe tilifertilizer on fields during dry periods, using sewage sludge biosolids and allowing livestock watering in streams can all contribute to fecal coliform contamination. Some waterborne pathogenic diseases that may coincide with fecal coliform contamination include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A and C. [Reduction] *Current treatments for the reduction* of fecal coliform in wastewater may require the use of chlorine and other disinfectant chemicals. Such materials may kill the fecal coliform and disease bacteria. However, [They] they also kill bacteria essential to the proper balance of the aquatic environment, endangering the survival of species dependent on those bacteria. So higher levels of fecal coliform require higher levels of chlorine, threatening those aquatic organisms. Municipalities that maintain a public water supply will typically monitor and treat for fecal coliforms. [In waters of the U.S., Canada and other countries, water quality is monitored to protect the health of the general public. In the U.S., fecal coliform testing is one of the nine tests of water quality that form the overall water-quality rating in a process used by U.S. EPA.] However, in certain situations, such as septic systems, wells, and cross-contamination in plumbing distal to the site where water quality is tested, provides a risk. [The fecal coliform assay should only be used to assess the presence of fecal matter in situations where fecal coliforms of non-fecal origin are not commonly encountered. EPA has approved a number of different methods to analyze samples for bacteria.] The sensor **132** communicates with the water use and water energy use monitoring display apparatus base station apparatus **10**, **126 50** through wired **133** (or wireless means) which includes specific software instructions to display the fecal coliform parameter on one of the displays or provide an alarm that is programmed that is triggered when [an] *a* certain level or percentage is exceeded.

Column 31, lines 3-46:

In [additional] addition, as shown in FIG. **4**, is an optional water hardness sensor **136**. [As pure water a good] *Water is an excellent* solvent and *easily* picks up impurities [easily and is often called the universal solvent. When water is combined] *Water combines* with carbon dioxide to form very weak carbonic acid *but carbonic acid has* even better solvent [results]*characteristics*. As water moves through soil and rock, it dissolves very small amounts of minerals [and holds them in] *creating a* solution [Calcium an] *of* magnesium [dissolved in water are] *and calcium,* the two most common minerals that make water "hard." The degree of hardness becomes greater as the calcium and magnesium content increases and is related to the concentration of multivalent cations dissolved in the water. Hard water interferes with [almost every] cleaning [task from] *task including* laundering [and], dishwashing [to], bathing, and personal grooming [Clothes laundered in hard water may look dingy and feel harsh and scratchy. Dishes and glasses may be spotted when dry.] Hard water may cause a film on glass shower doors, shower walls, bathtubs, sinks, faucets, etc. [Hair washed in hard water may feel sticky and look dull.] Water flow may be reduced by *mineral* deposits in pipes. [Dealing with hard water problems in the home can be a

nuisance.] The amount of hardness minerals in water *also* affects the amount of soap and detergent necessary for cleaning. Soap used in hard water is less effective as it combines with [the] minerals to form a [sticky soap] soapy curd. [Some] *Similarly*, synthetic detergents are less effective in hard water because the active ingredient is partially inactivated by hardness [, even though it stays dissolved]. Bathing with soap in hard water leaves a film of [sticky soap] *soapy* curd on the skin. [The film may prevent removal of soil and bacteria. Soap] *Soapy* curd interferes with the return of skin to its normal, slightly acid condition, and may lead to irritation. [Soap] *Soapy* curd on hair may make it dull, lifeless, and difficult to manage. When doing laundry in hard water, [soap] *soapy* curds lodge in fabric during washing to make fabric stiff and rough. [Incomplete] *This results in incomplete* soil removal from laundry causes graying of white fabric and the loss of brightness in colors. [A sour odor can develop in clothes. Continuous laundering in hard water can shorten the life of clothes.] In addition, [soap] *soapy* curds can deposit on dishes, bathtubs and showers, and all water fixtures. Hard water also contributes to inefficient and costly operation of water-using appliances. Heated hard water forms a scale of calcium. and magnesium minerals that can contribute to the inefficient operation or failure of water-using appliances. Pipes can become clogged with scale that reduces water flow and ultimately requires pipe replacement.

Column 31, lines 61-67 to Column 32, lines 1-2:

In addition, as shown in FIG. **4**, is an optional pH sensor **134**. Various pH sensors available in the current market can be utilized with the present invention. The sensor **134** communicates with the water use and water energy use onitoring display apparatus base station apparatus **10**, **126** through wired **135** (or wireless means) which includes specific software instructions to display the pH parameter on one of the displays or provide an alarm that i programmed that is triggered when [an] *a* certain level or percentage is exceeded.

Column 37, lines 1-10:

The present invention can also use RF mesh technology, which allows *water* meters and [other sensing devices] *hub devices* to securely route data [via] *to* nearby meters and *hub* relay devices, creating a "mesh" of network coverage. The system supports two-way *or full duplex* communication between the water use and water energy use monitoring display apparatus base station **10** (and **126** In FIG. **6**) and the remotely positioned display and/or recorder receiver apparatus **50**, **56** and can be [upgraded] remotely *uploaded*, providing the ability to implement future innovations efficiently [easily and securely].

Column 37, lines 11-24:

The [electric] *water meter* network access point collects data and [periodically] transfers this *water use* data to defined *water* to *a* defined municipality [via] *utilizing* a secure cellular network. Each RF mesh-enabled [device (meters, relays) is] *water meter and relay devices* are connected to several other mesh-enabled devices, which function as [signal] *data* repeaters, [relaying] *transferring* the data [so] to an access point. The access point device aggregates, encrypts, and [sends] *transfers* the data [back] to municipality or governmental agency over a secure commercial third-party network. The resulting RF mesh network can [span large] *extend over long* distances and reliably transmit data [over rough or difficult terrain]. If a water meter or other transmitter drops out of the network, [its neighbors find] *it finds* another route. The mesh [continually] *technology* optimizes routing to ensure [information] *data* is [passed] *transferred* from its source to its destination as [quickly and] efficiently as possible.

Column 39, lines 20-38:

Coordination of data packet transmissions from the highly sensitive flow sensors **120***a*, **120***b*, **121** and **123** can be scheduled. The water use and water energy use monitoring display apparatus base station **10**, **126** can run a master schedule for querying each flow sensor **120***a*, **120***b*, **121** and **123**. For example, the water use and water energy use monitoring display apparatus base station **10**, **126** can transmit a massage to a specific coordinator node **18** and that coordinator node can then sequentially request data from each of its flow sensors **120***a*, **120***b*, **121** and **123**. This systematic process can reduce data packet collision on the network and make the use and water energy use monitoring display apparatus base station **10**, **126** immediately aware of any flow sensor **120** *a*, **120** *b*, **121** **43** that might be having trouble transmitting its data packet. The water use and water energy use monitoring display apparatus base station **10**, **126** can transmit an acknowledgment to each highly sensitive flow sensors **120** *a*, **120** *b*, **121** and **23** after successfully processing a data packet.

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **1-8**, **13-16** and **18-20** were previously cancelled.

Claims **9-12** and **17** are cancelled.

New claims **21-41** are added and determined to be patentable.

21. A residential or commercial building or structure water meter comprising:

a base station comprising therein a water control valve mechanism, said base station interposed between a water line from a water main and a water supply for said building or structure;

said base station further comprising therein:

(a) said base station having at least one joint connector for attaching to one or more input water lines and at least one joint connector for attaching to one or more output water supplies;

(b) an electrical circuitry comprising a power source and at least at least one of a CPU and microprocessor;

(c) a display in electrical communication with the electrical circuitry;

(d) the at least one of a CPU and microprocessor comprising an integrated memory bank or memory bank located as a separate memory module;

(e) the at least one of a CPU and microprocessor having the capability to to monitor at least one of a water use data, water duration, and water total volume, or selecting a programming alarm state or setting, change units for US or international standards, and perform timing parameters;

(f) one or more flow rate sensors in communication with said water supply and electrically connected with said electrical circuitry;

(g) one or more wireless communication technologies having the capability to transfer water parameter data utilizing confidential technology from the base station to at least one of a private, commercial, and third-party network to a remote offsite central monitoring computer;

the confidential technology comprising at least one of an encryption, authentication, integrity, and non-repudiation technology that originates from the base station;

wherein at least one of a cell phone, mobile phone, and one or more remote electronic apparatuses are capable of downloading water parameter data from the offsite central monitoring computer;

the base station having a unique identification method comprising at least one or more characters, numbers, and symbols that is visually observable on the base station or in the software that is at least one of a MAC address, Universal Unique Identifier (UUID), TCP/IP address, DNS name, owner's email address, serial number, or an unique string of characters issued by a municipal or governmental agency.

22. The residential or commercial building or structure water meter of claim 21, wherein said at least one of a remote display and recording apparatus, remote computer, cell phone and mobile phone, can retrieve at least one of a water use and a water quality data over at least one of the internet, cell tower, third party network and private network from the offsite central computer monitoring station.

23. The residential or commercial building or structure water meter of claim 21, at least one of a remote display and recording apparatus, remote computer, and cell phone or mobile phone for remote monitoring by at least one of a residential user, commercial occupier, and municipal or governmental agency.

24. The residential or commercial building or structure water meter of claim 21, further comprising one of more water control valve mechanisms that are controlled by at least one of a CPU and microprocessor instructions.

25. The residential or commercial building or structure water meter of claim 21, wherein said confidential technology utilizes encryption technology to securely provide water parameter information or data in a confidential format.

26. The residential or commercial building or structure water meter of claim 21, wherein said confidential technology utilizes authentication procedures to ensure that transferred, uploaded, or downloaded information and/or data is communicated to an intended water meter.

27. The residential or commercial building or structure water meter of claim 21, wherein said confidential technology utilizes integrity techniques to ensures that a message, information or data does not alter in any way during wireless transmission.

28. The residential or commercial building or structure water meter of claim 21, wherein said confidential technology utilizes non-repudiation methods that prevents a sender from denying that a message, data or information was sent by said wireless or wired communication means.

29. The residential or commercial building or structure water meter of claim 21, wherein said one or more wireless communication technologies can transmit water parameter data or information to an offsite monitoring central station or private network with remote computer, cell phone or mobile phone on a frequency of at least once per minute, once per hour, and once per day, per month, and per year.

30. The residential or commercial building or structure water meter of claim 21, wherein said wireless communication technologies can transmit water parameter data or information to an office monitoring central station with remote computer, cell phone or mobile phone on a water use period wherein the CPU or microprocessor monitors water parameters upon the initiation of water use until water use is stopped.

31. The residential or commercial building or structure water meter of claim 21, further comprising at least or one or more sensors for monitoring one or more halogen elements or compounds, one or more sensors for monitoring total dissolved solids, one or more sensors for nit ing a metallic or iron element or compound, one or ore sensors for monitoring water hardness, one or more sensors for monitoring biological or coliform contaminates, and one or more sensors for monitoring pH.

32. The residential or commercial building or structure water meter of claim 21, further comprising one or more independent and separate water sensors each having a wireless radio frequency (RF) transceiver that are designed to detect water leaking near water use devices, fixtures, and appliances.

33. The residential or commercial building or structure water meter of claim 21, wherein the water control valve mechanism is controlled by programming instructions from at least one of a CPU and microprocessor for turning on and off said water control mechanism in response to local or remotely received instructions.

34. The residential or commercial building or structure water meter of claim 21, wherein the water control valve mechanism is controlled by programming instructions from at least one of a CPU and microprocessor for turning on and off said water control mechanism in response to observed water leak.

35. The residential or commercial building or structure water meter of claims 21, wherein one of said one or more wireless communication technologies communicates with an offsite central monitoring with remote computers utilizing at least one of a satellite communication, microwave technology, the internet, cell tower, and telephone lines.

36. The residential or commercial building or structure water meter of claim 21, wherein said one or more wireless communication technologies is in an IP or DHCP protocol and wherein said IP or DHCP protocol and allows said apparatus to access and communicate over the Internet.

37. The residential or commercial building or structure water meter of claim 21, wherein said wireless communication technologies has a frequency in the range of 902 MHz to 928 MHz.

38. The residential or commercial building or structure water meter of claim 21, wherein said wireless communication technologies is in a frequency range of 902 MHz to 928 MHz that transfers at least one of a water use, water energy use, and water quality data to at least one of a private, commercial, and third-party network.

39. The residential or commercial building or structure water meter of claim 21, wherein said one or more wireless communication technologies is a cellular technology.

40. The residential or commercial building or structure water meter of claim 21, wherein said one or more wireless communication technologies is a Wi-Fi technology.

41. The residential or commmercial building or structure water meter of claim 21, wherein said one or more wireless communication technologies is at least one of a cellular technology, Wi-Fi technology, IEEE 802.15.4 format, Zigbee, Z-Wave, Bluetooth technology, a radio frequency in the

range of 902 MHz to 928 MHz, and an Industrial, Scientific, and Medical (ISM) band in the range of 6.765 MHz to 245 GHz.

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